Towards a new PAR for IEEE 802.1 TSN

Flow Metering for Guaranteed Low-Latency of Industrial Control-Data Streams

IEEE 802.1 Interim Meeting - Sept. 2014, Ottawa, Canada

Feng Chen, Franz-Josef Goetz, Marcel Kiessling,
Siemens AG

SIEMENS

Contents

Recap: Features and Requirements of Industrial Communication at Different Levels

Features	Field-Level	Control-Level	Plant-Level
Link Speed	100 MBit or less	>= 1 GBit	
Max. Stream Bandwidth	< 50%	< 15%	?
Typical Traffic	Control-Data-Streams	slow Control-Data-Streams AV-Streams	AV-Stream for diagnostic and measurement
	… mixed with Synchronization, Network Control and Best-Effort-Traffic		
Transmission cycle **(TC)**	31,25 µs		10ms
Low latency	Closed-Loop-Applications **~ <= 20% of TC** Control-Applications **~ TC** *(Open Systems)*	Control-Applications **~ TC** *(Open Systems)*	Application dependent **~ 2.. 10ms**
Transmission modes	scheduled and coordinated or scheduled	periodical or scheduled	periodical
Max. frame size	64 byte		600 byte
Topology	simple topologies Daisy Chains or Rings (e.g. 64 2-Port devices)	more complex topologies e.g. combination with rings, coupled rings, trees and stars, …	
Flexibility	Closed Systems with less requirements on flexibility	High requirements on flexibility Add and remove of streams at runtime without any effect on established streams	
Seamless Failover	single Rings	ISIS-PCR for more complex topologies and flexibility	
Path reservation	**Closed-Systems** with Static path reservation		
	Open-Systems with dynamic path reservation at runtime		
Bandwidth & resource reservation	is required for guaranteed QoS		
	Closed-Systems with static configuration **Open-Systems** with dynamic configuration	**Open-Systems** with dynamic configuration	Dynamic configuration

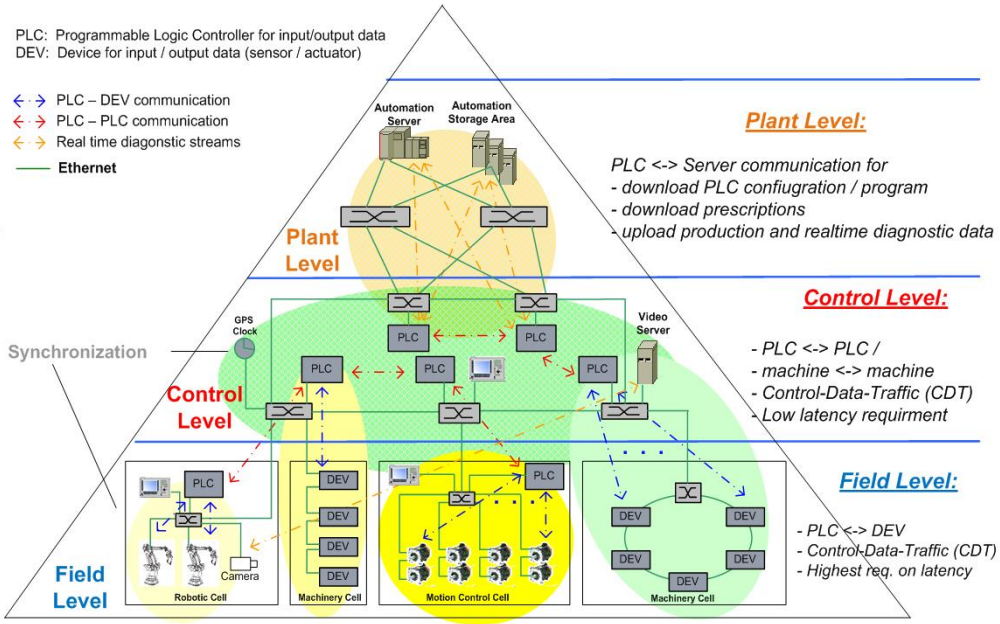
http://www.ieee802.org/1/files/public/docs2014/new-tsn-kiessling-Shaper-0714-v01.pdf

Recap: Desired Solutions for Industrial Control Applications on Different Levels

Features	Field-Level	Control-Level	Plant-Level
TSN solutions for industrial control systems with predominant requirements	Closed Systems: TAS (802.1 Qbv) for lowest latency	Open Systems: **SP + Flow Metering** for guaranteed low latency	SQF for low-jitter AV Streams
	Open Systems: **SP + Flow Metering** for guaranteed low latency		

How to guarantee low-latency for control data streams in industrial open systems

- transmit control-data streams with highest priority (no shaping applied)
- apply flow metering (policing) on both ingress and egress ports
  - limit receiving and transmitting rates by discarding non-conformant frames
  - detect misbehavior and prevent failure propagation
  - enable diagnostics



SIEMENS

A Overview of Flow Metering in 802.1Q

- 802.1Q specifies flow metering (in sub-clause 8.6.5)
  - is an ingress policing mechanism (located after filtering before queues)
  - only minimally specified for maximum flexibility (just a framework)
    - assignment of frame to meters (flow classification) left open
    - the metering algorithm not specified
    - how to deal with colored frames in queue management very loosely specified
- MEF bandwidth profile algorithm is referenced and recommended in 802.1Q
  - is a Token Bucket based two rate three color algorithm
    - color interpretation (G: committed; Y: excess; R: non-conformant)
  - can be configured to be a single rate three (or two) color version
  - operates in “color aware” or “color blind” (color is a global or local value)
  - handling of colored frames (G: let go; Y: forward in best efforts; R: discard)

http://www.ieee802.org/1/files/public/docs2013/new-tsn-haddock-flow-metering-in-Q-0113-v01.pdf

http://www.avnu.org/files/static_page_files/90CCC9EF-1D09-3519-AD34763EC820D48D/AVnu%20AAA2C_Ingress%20Policing_Rodney%20Cummings.pdf

Industrial Requirements for Flow Metering in TSN
1. Why Flow Metering is Needed at Ingress Ports?

SIEMENS

- Flow metering at ingress ports meters receiving rate of incoming frames of a specified flow

  In AVB/TSN, we focus primarily on streams, such as AV-streams and control-data streams, which are a subset of flow with special characteristics or requirements (unidirectional from one talker to one or more listeners, typically periodic data, requiring e.g. low-latency, shaping, bandwidth reservation, seamless redundancy …) . Thus we need to consider stream as a basic unit of flow metering in TSN, i.e. using a meter for one single stream, an aggregation of streams, or all streams of the same priority (per class).

  - detect overload situation caused by failures e.g. misbehaved talkers or bridges at an earlier time (before switching)

  - discard non-conformant frames to prevent failure propagation to egress port

    - passing a faulty stream (typically overloaded with an excessive burst size) may exhaust resources in its transmission queue, causing delay or drop of other normal streams (possibly received from other ingress ports) in the same queue.

  - conducting ingress metering on a per-stream base can achieve most accurate results

    - enable stream-based failure detection for control-data streams or AV streams

Earlier presentation on ingress policing for TSN streams:

http://www.ieee802.org/1/files/public/docs2014/tsn-chen-ingress-policing-0714-v1.pdf

Industrial Requirements for Flow Metering in TSN
2. Why Flow Metering is Needed at Egress Ports?

SIEMENS

- Flow metering at egress ports meters transmitting rate of outgoing frames of specific streams
  - shaping is not suitable for control-data streams with low-latency requirements, because it delays frames. SP serves low-latency better for control-data streams of highest priority.
  - in addition to SP, egress metering performs bandwidth control for control-data streams by discarding non-conformant frames on a per-class base.

why do we still need flow metering at egress ports, if already having them on ingress side

(here per-stream ingress metering scheme assumed)?

- ingress metering should react only to excessive incoming frames caused by failures
- in normal cases, frames arriving at ingress ports with jitter in their inter-arrival time may form temporal overload -> **ingress metering must let jittered-streams through!**
- multiple control-data streams of the same class with jitters received on different ingress ports may form a burst of an excessive size in their common transmission queue

-> egress metering must limit such bursts, in order to protect other classes of lower priorities

Concept of Flow Metering for TSN
1. Leaky bucket or token bucket for flow metering?

SIEMENS

- Deployed as a meter, leaky bucket or token bucket are simply two mirrored process in their basic algorithms.

Interpretation	Leaky Bucket	Token Bucket
Reserved bandwidth e.g. a rate of A bits/s	removing token at a rate of A	adding token at a rate of A
Consumed bandwidth e.g. receive or transmit B bytes	adding token of B bytes	removing token of B bytes
Overload indicator	adding B bytes causes bucket overflow or exceeding a specified max level	no enough token for B bytes left in the bucket

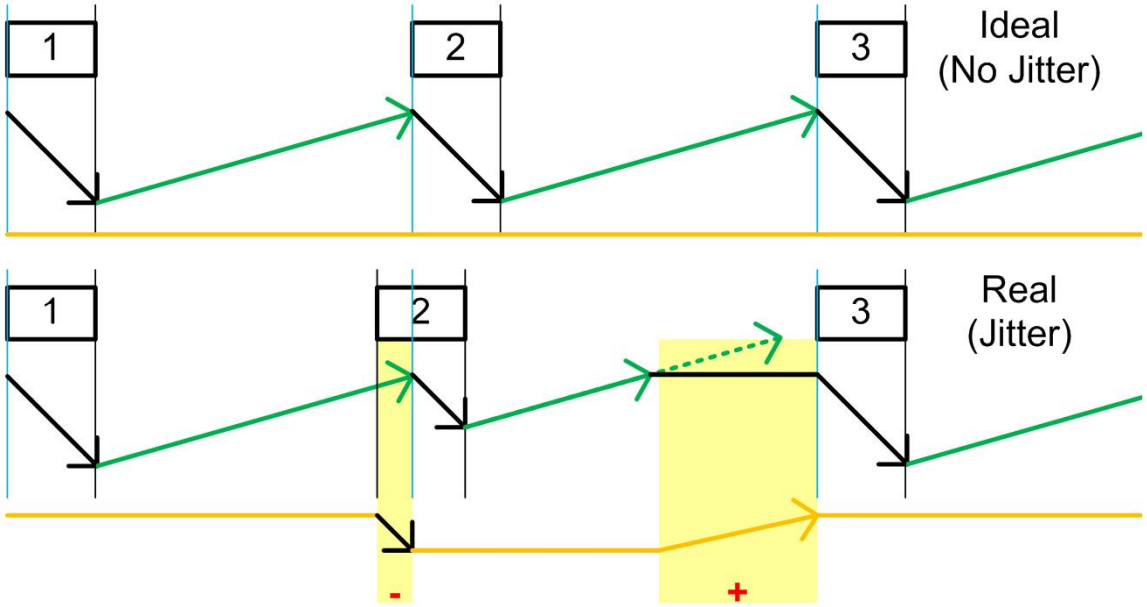
- More important is to define a metering scheme (based on leaky/token bucket) with functions that meet meet our requirements
  - e.g. CBSA is typically regarded as a special case of leaky-bucket algorithm by setting max_level to 0 (no burst allowed in normal case) and allowing positive credits for accumulating credits during an ongoing transmission of interfering traffic.

Concept of Flow Metering for TSN
2. What Kind of Flow Metering Scheme do We Need?

- Flow metering is needed for both ingress and egress ports.
  - on ingress ports: per stream policing is desired and needed for control-data stream, can be also be applied to other streams like AV-streams
  - on egress ports: per-class policing scheme for control-data class
- Coloring scheme
  - color blind, i.e. color is valid only locally on ports, not propagated from ingress to egress and also not to next station
  - three colors (G, Y, R) can be deployed, where Y can be
    - MEF defines that Y frames are transmitted with “Best efforts” (lowered priority), which is not desired for control-data streams, because doing that will overload best efforts traffic
    - Y may be used to indicate frames received or transmitted using extra bandwidth reserved for purpose of jitter tolerance.
    - to support jitter tolerance, a new flow metering algorithm is needed

Concept of Flow Metering for TSN
3. An Example of Flow Metering Algorithm

- two buckets algorithm (one for reserved bandwidth, one for jitter)



Thank you for your attention!

Feng Chen

I IA ATS TM5 1

Gleiwitzer Str. 555

90475 Nürnberg

Phone: +49 (911) 895-4955

Fax: +49 (911) 895-3762

E-Mail: chen.feng@siemens.com

siemens.com/answers